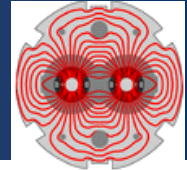


Quench Test strategy WG

Introduction

Mariusz Sapinski BI/BL

CERN, 16 March 2012



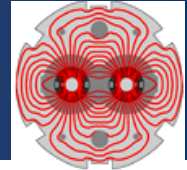
In past 3 teams actively interested in quench tests:

- BLM for thresholds
- Collimation for performance
- MPP

Different opinions concerning the methods to perform tests and interpretation of results.

Just before Chamonix:

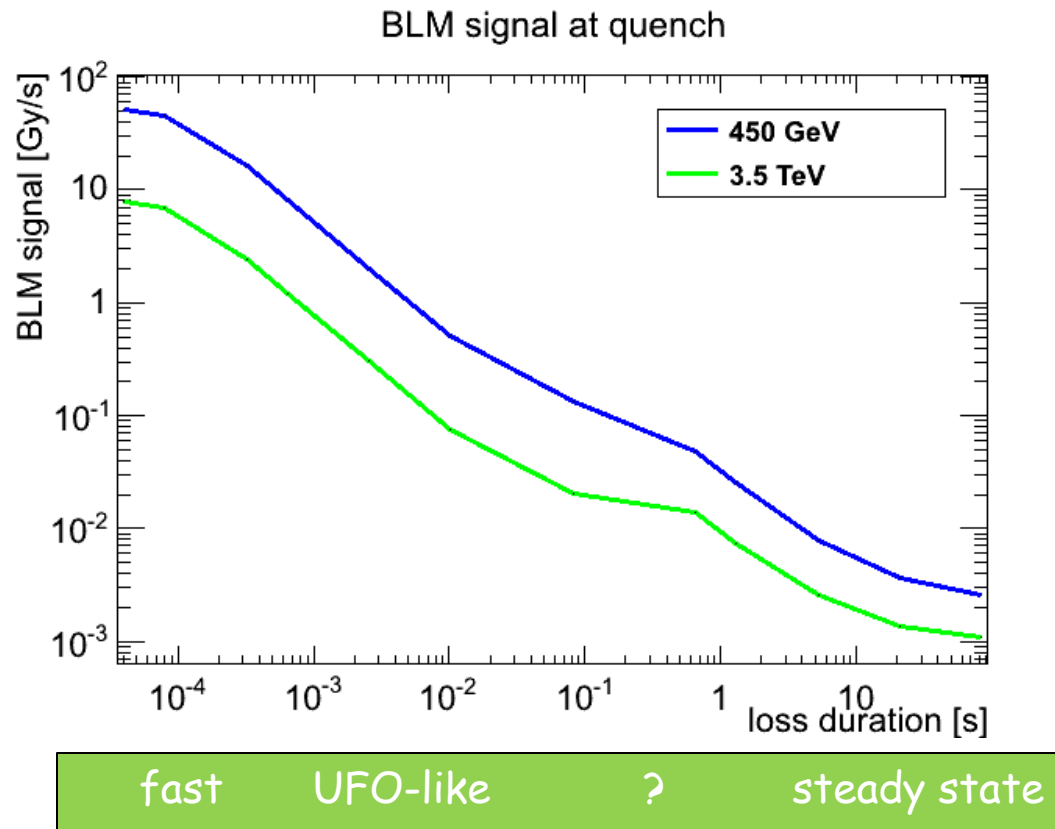
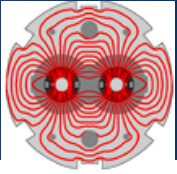
- Rudiger: proposal for quench limit workshop after summer
- Bernd: after summer is too late, we should meet and prepare tests before

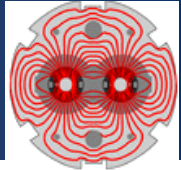


- Discuss the importance and plan in quite detail quench tests (to be performed in 2012) which are needed to operate LHC after LS1.
- Give coherent output to management.

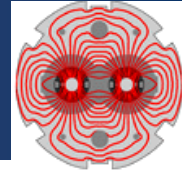
- Meetings: about once per month
- Close relation to Machine Protection Panel and BLM threshold WG.

3 main types

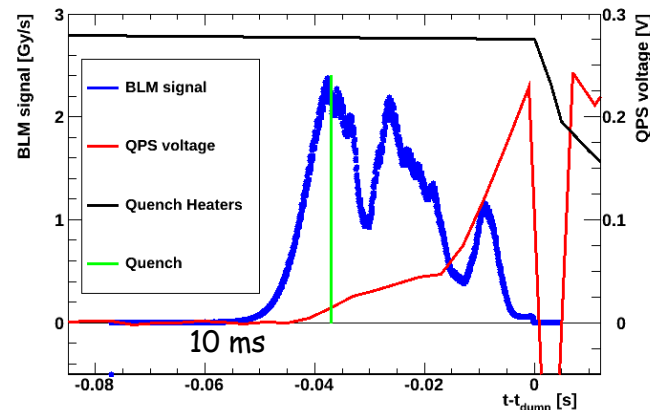
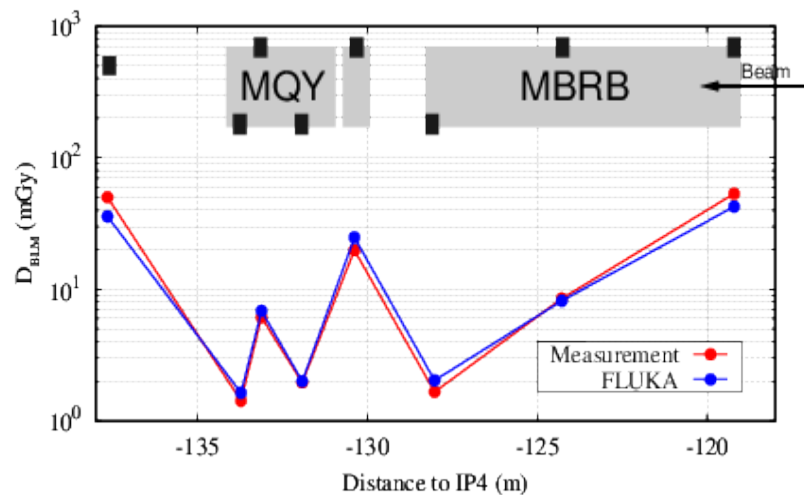




- Single turn losses at injection energy.
- 7 quenches of this kind:
 - On the ring: two in 2008, two in 2009, one in 2011
(LHC Proj Note 422)
 - Injection (many magnets involved): 2010 and 2011
- In addition a quench test when injected beam was dumped on collimator (TCLIB) - magnet current were ramped (increasing magnet sensitivity to quench) - no quench occurred. *(ATS-Note -2011-067 MD)*
 - FLUKA simulations - soon; they will allow to understand the results (lack of quench).
 - In 2012 this test could allow to determine easily the $QL(E_{\text{beam}})$ for short losses (UFO quenches as a function of beam energy?).

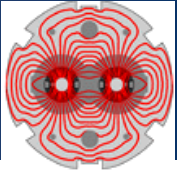


- Highly recommended to be studied (Chamonix 2012 workshop) as UFOs can be limitation to lumi production after LS1.
- Wire scanner quench test done in 2010
- Lack of UFO-generated quenches



(ATS-Note -2011-062)

	energy density [mJ/cm ³]		
	FLUKA and experiment	QP3, dry coil, FLUKA radial shape	Current method
cable average	11.6	15.6	70



Strategy A

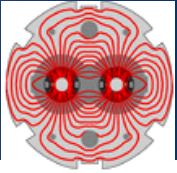
1. Repeat wire scanner test with shorter duration
2. Perform orbital bump test on the same magnet with the same timescale (using ADT)
3. Results extrapolated to other magnets using FLUKA/G4+QP3 code

Advantages:

1. Detailed FLUKA simulation exists
2. Only way to assess directly difference between UFO and bump loss

Disadvantages:

1. MBRB magnet (4.5 K) - is special -> QP3
2. MBRB - only one spare -> end of run
3. Different geometry than for the arc -> FLUKA/G4



Strategy B:

1. UFO *fishing*

i.e. increase BLM thresholds in cells with healthy splices and extra BLMs
and **wait for UFO to quench**

2. Set BLM thresholds according to registered signal, get Quench Limit from FLUKA/G4

Advantages:

1. Real UFO quench

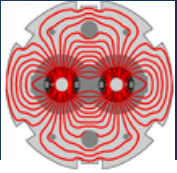
We should not rely on this option only

Disadvantages:

1. Quench may not happen

2. UFO location and size not well controlled

3. the FLUKA/G4 accuracy in terms of Quench Limit reduced



Strategy C:

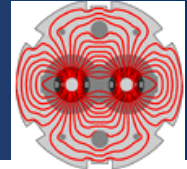
1. Orbital bump test in millisecond scale with ADT on arc
2. Use FLUKA/G4 to extrapolate results to UFO-like loss

Advantages:

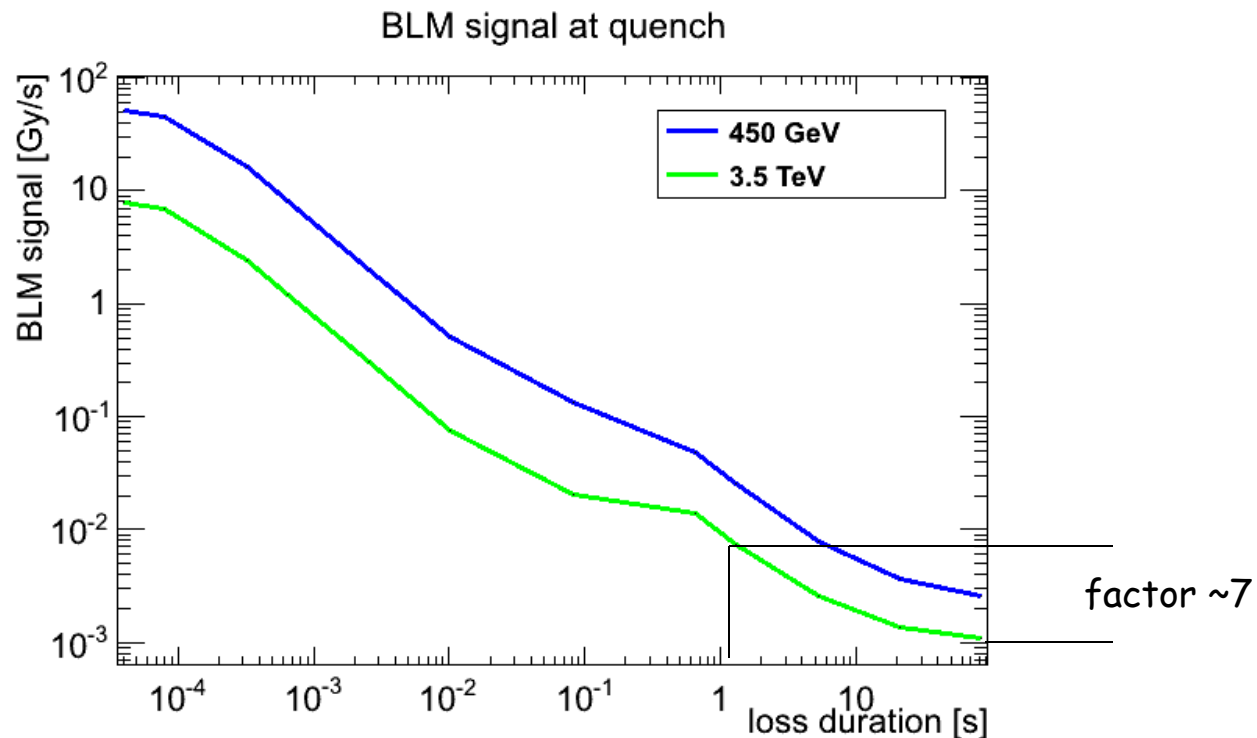
1. Arc magnet used (most abundant)

Disadvantages:

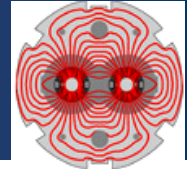
1. No direct testing of the difference between UFO and bump loss.



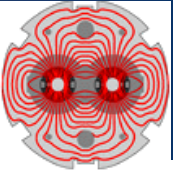
- LHC performance depends on steady state quench limit which remains not well known.
- During MD in 2011 we have reached nominal power on collimators without quenching for 1 s losses



- Two complementary approaches are possible: orbital bump or dispersion suppressor.
- For me this is very important as we plan very-high lumi runs.

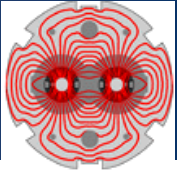


- Chamonix priority are UFO losses.
There are a few ways to investigate them.
- Steady state would be good to test.
- We have tools which may still turn to be very useful:
 - ADT
 - QPS scope
 - cryo measurements (K. Brodzinski, next MPP)
- Do we miss something?
 - 0.1 s losses: Ralph claimed they often appear in operation



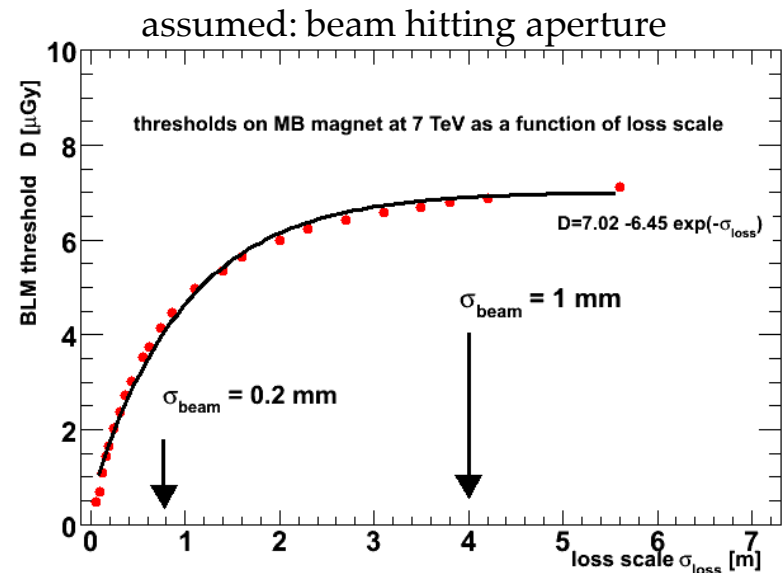
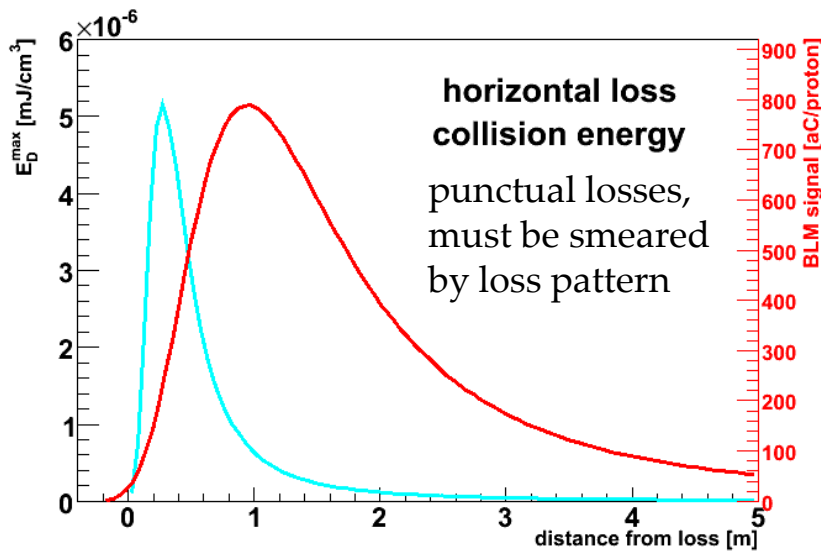
THANK YOU FOR YOUR ATTENTION!

REST OF THE SLIDES ARE SPARE (CHAMONIX 2011)

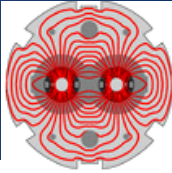


- Quench Limit can be expressed in BLM signal [Gy/s] at which the magnet quenches.

- BLM signal (S_{BLM}) at Quench is: $S_{BLM} = R \cdot QL(E, t); \quad R = E_{BLM} / E_{coil}$



- In most cases: $mJ/cm^3 \neq Gy/s \neq protons/s \neq W/m$
- Considering all parameters QL determination accuracy is factor 2-3...



- List of beam-induced quenches on sharepoint page <http://cern.ch/biq>
- Up to now 13 quenches, 10-test, 3-injection events

cern.ch https://espace.cern.ch/BIQ/List of quenches/Forms/Default.aspx

Most Visited LHC strona glowna/main pa... AstroNEWS - Astrono... FEPN - Festival Europ... Latest news, comment... Image Processing Tut...

Beam Induced Quenches in the LHC Welcome Mariusz Gracjan Sapinski |

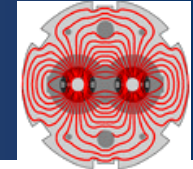
Beam Induced Quenches in the LHC

Home Site Actions

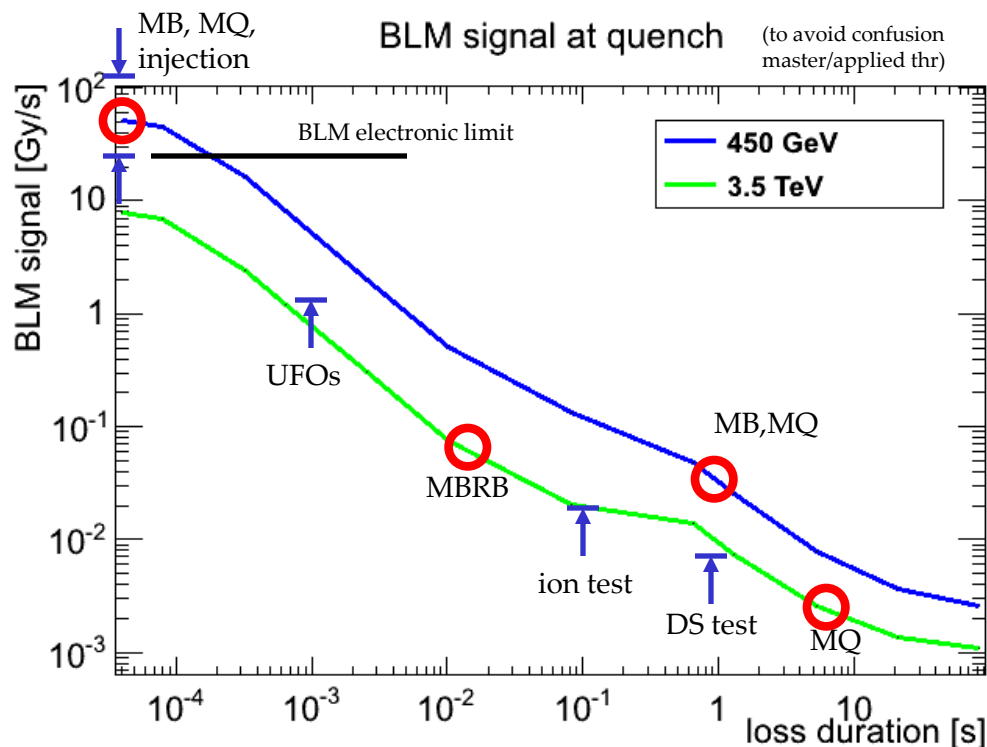
Beam Induced Quenches in the LHC > List of quenches

List of quenches

Type	Name	Modified	Modified By	Magnet	Location	E_beam	Duration	Beam	Plane
Folder	2008-08-09 (00h19m51s)	03/08/2011 03:06 PM	Arjan Verweij	MB	8L3	0.45	ns	B1	V
Folder	2008-09-07 (15h34m05s)	03/08/2011 03:22 PM	Arjan Verweij	MB	10R2	0.45	ns	B1	V
Folder	2009-11-20 (18h21m27s)	03/08/2011 03:24 PM	Arjan Verweij	MB	12L6	0.45	ns	B1	H
Folder	2009-12-04 (10h19m49s)	03/08/2011 03:36 PM	Arjan Verweij	MB	15R2	0.45	ns	B1	V
Folder	2010-04-18 (10h33m41s)	03/08/2011 03:36 PM	Arjan Verweij	MB+	20R1	0.45	ns	B1	V?
Folder	2010-10-06 (08h13m58s)	03/08/2011 03:36 PM	Arjan Verweij	MQ	14R2	0.45	1 s	B2	V
Folder	2010-10-06 (10h35m01s)	03/08/2011 03:36 PM	Arjan Verweij	MQ	14R2	0.45	1 s	B2	V
Folder	2010-10-06 (11h37m00s)	03/08/2011 03:36 PM	Arjan Verweij	MB	14R2	0.45	1 s	B1	H
Folder	2010-10-17 (18h23m14s)	03/08/2011 03:36 PM	Arjan Verweij	MQ	14R2	3.5	6 s	B2	V
Folder	2010-11-01 (14h40m04s)	11/09/2011 12:26 PM	Mariusz Gracjan Sapinski	MBRB	5L4	3.5	20 ms	B2	-

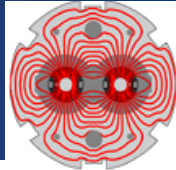


- 14R2 quench test (2010)
- Wire scanner quench test
- Dispersion suppressor quench tests
(protons and ions)
- Injection quench events

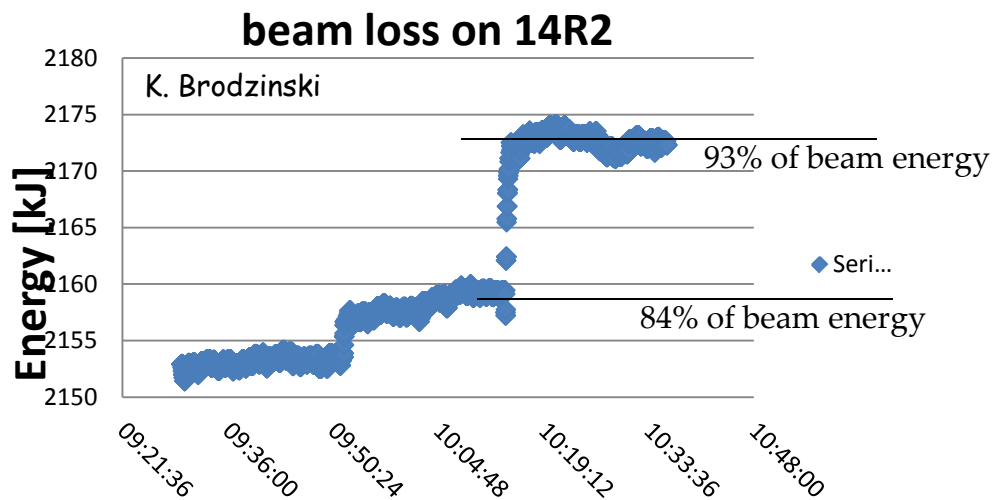


We measure BLM signals and lost beam intensity.

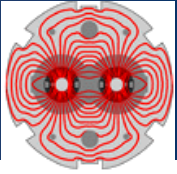
Monte Carlo simulations allow to conclude about Quench Limits [mJ/cm³].



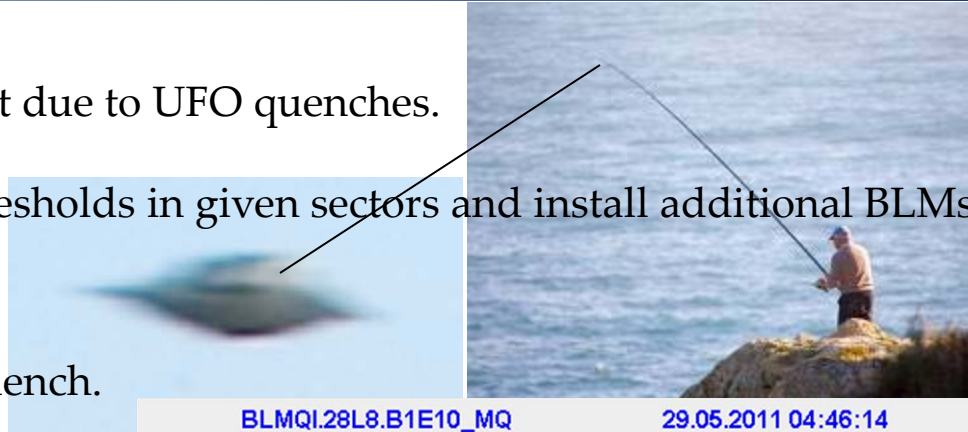
- It is proposed to repeat this test in 2012:
 - Quench with raising orbital bump (better horizontal this time).
 - 2nd ramp with orbital bump amplitude steered by BLM orbit feedback at 50-80% of BLM signal of previous quench. Alternatively: bump + ADT blowup.
 - **Expected: steady-state loss lasting ~1 minute, without quench.**
 - Real steady-state quench limit determination in well-controlled, clean conditions.
 - Cryogenic calorimetry and QPS scope measurements



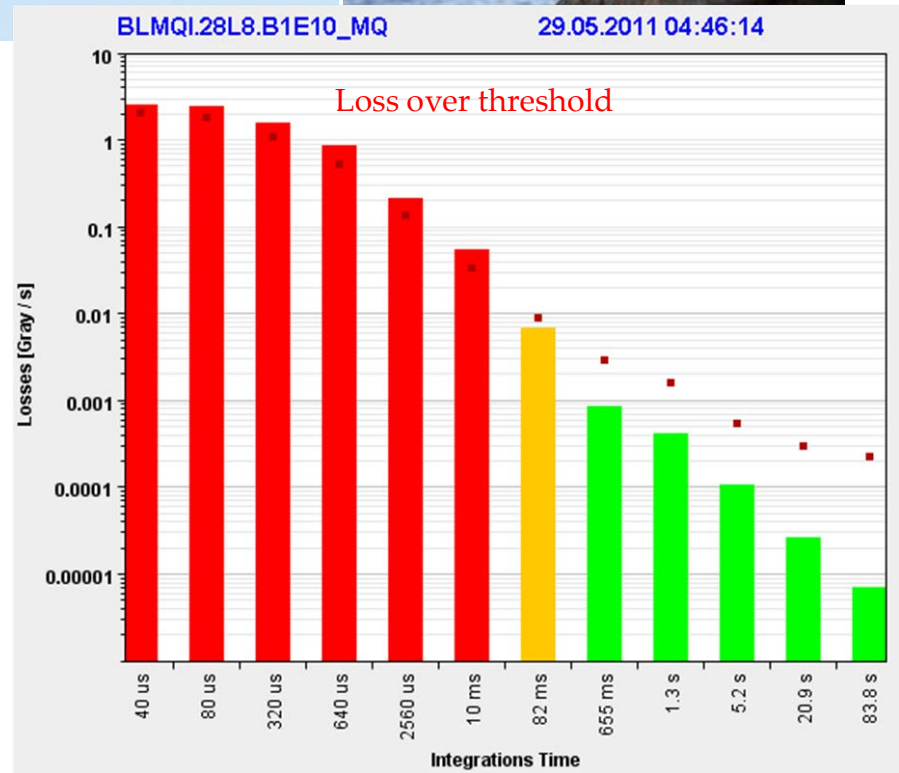
	QPS	scope
sampling	500 S/s	20 kS/s
resolution	5 mV	0.3 mV

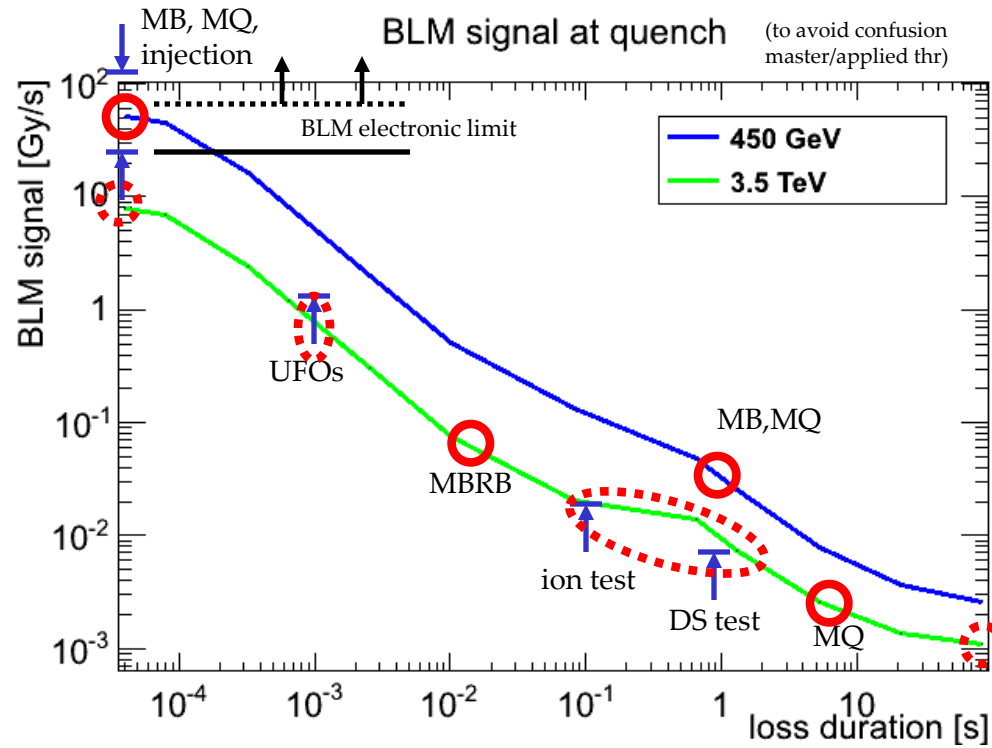
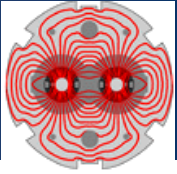


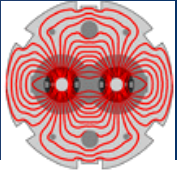
- ❑ Need to know operational limit due to UFO quenches.
- ❑ It is proposed to raise BLM thresholds in given sectors and install additional BLMs in chosen locations (Q18,19 R3).
- ❑ Wait for the UFO-generated quench.
- ❑ Simulations are being prepared.
- ❑ More in Tobias' presentation.



Example of UFO in cold sector
which dumped the beam.







BLM thresholds on cold elements:

$$T(E_b, L_s(x, y, z), L_t(t)) = \overset{\text{quench limit}}{\Delta Q}(E_b, L_t(t)) * \overset{\text{BLM signal}}{S_{BLM}}(E_b, L_s(x, y, z)) / \overset{\text{energy deposited in coil}}{E_d}(E_b, L_s(x, y, z))$$

$L_s(x, y, z)$ - spatial distribution of loss

$L_t(t)$ - loss duration (or evolution timescale)

E_b - beam energy

o) S_{BLM} is measured and simulated, E_d is only simulated, but accuracy of this simulation is controlled by S_{BLM} .

o) quench limits ΔQ are best known for fast transient losses (cable enthalpy) and steady state losses (heat evacuation to cryogenic system) -

ΔQ in milisecond scale?

o) $L_s(x, y, z)$ corresponds beam impacting on the beam screen over many meters

(240 μ rad) - UFO is similar to loss generated by Wire Scanner

